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THE UNIVERSITY OF ALBERTA

RESPONSES TO LACTATION

(C)

BY

WILMA MARSHALL

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND
RESEARCH IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF EDUCATION
IN
COUNSELLING PSYCHOLOGY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA
FALL, 1987

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Responses to Lactation" submitted by Wilma Marshall in partial fulfillment of the requirements for the degree of Master of Education.

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ABSTRACT

This study was designed to determine if there were consistent patterns of significant observable peripheral physiological change which occur during breastfeeding. More specifically, the purposes of this exploratory study were the investigation and description of physiological changes hypothesized to occur during lactation as these relate to behavioural sequences during a feeding.

Given parallel temporal sequences of significant milk flow and oxytocin increases, feedings were divided into three significant periods or stages: Volition (the period when feeding is being initiated, but prior to suckling); Two Minutes (the period which ends two minutes after feeding is initiated); and Five Minutes (the period which ends five minutes after feeding is initiated). Finger temperature, skin conductance response, and breast temperature were recorded at these stages and subsequently compared to each other and to baseline data established prior to feeding. The peripheral measures were chosen for their potential to indicate the level of sympathetic arousal, the possible relation between oxytocin level and peripheral vasodilation, and the possible relation between increased breast temperature

and milk flow as a result of oxytocin release.

Data were recorded from twenty breastfeeding mothers whose infants were between six weeks and six months old. None of the infants were being fed solid food or supplemental formula; all were full-term and gaining well.

A series of one-way repeated measures ANOVA indicated significant changes during feeding in each of the physiological measures. Significant increases in finger temperature occurred relative to baseline and volition at two minutes and five minutes. Skin conductance response increased significantly between baseline and volition, and had decreased significantly compared to volition by five minutes. Significant increases in breast temperature occurred relative to baseline at two minutes and five minutes.

Possible roles for adjunctive biofeedback intervention to foster the milk-ejection reflex in a variety of circumstances were discussed. Implications of the results of this study, and directions for subsequent research were addressed.

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CHAPTER ONE

INTRODUCTION

A. CHAPTER OVERVIEW

Chapter one serves as an introduction to the study. Included is a chapter outline, an overview of the theoretical perspective provided by psychophysiology, and, in conclusion, a brief rationale for the use of this perspective and its approaches in research on lactation.

B. THEORETICAL ORIENTATION

Physiological psychology defines itself as the study of the biology of psychological processes (Levitt, 1981). As such it begins with the nervous system of the organism, manipulates a physiological variable, and then observes the effects on behaviour. Physiological psychology typically aligns itself with neuroscience and neurobiology. In contrast, psychophysiology begins with an emotional, mental, or behavioural condition, manipulates this psychological variable, and observes the effects on physiological responses (Feuerstein, Labbe, and Kuczmierczyk, 1986). Psychophysiology typically aligns itself with health psychology and behavioural medicine. Porges and Coles (1976) further

elaborated the distinction between these two subspecialties:

> Psychophysiologists are concerned with the effects of manipulating psychological variables on physiological responses that are generally detectable without intrusion into or violation of the physiological integrity of their subjects; [whereas,] physiological psychologists often manipulate the physiological status of their subjects while observing behavioral effects. (p.1)

The psychophysiology of emotion (Lang, Rice, and Sternbach, 1972), of sleep (Snyder, 1970), and of the detection of deception (Orne, Thackray, and Paskewitz, 1972) are among the various topics investigated using this perspective and methodology. Contributions have similarly been made to our understanding of intelligence and performance (Mulcahy, 1975), and to psychopathology (Alexander, 1972).

C. PSYCHOPHYSIOLOGY AND LACTATION

One aspect of human behaviour not extensively researched to date, and yet which would appear to lend itself well to psychophysiology's research perspective and methods is lactation. Mason (1972) considers psychoendocrine mechanisms to be the physiological foundation of research in psychophysiology, and in this regard, one of the critical aspects of the physiology of

study is to investigate and describe physiological changes hypothesized to occur during lactation as these relate to the behavioral sequences during a feeding.

Meites (1974) has suggested the direction for subsequent research in this area:

> The knowledge gained in the past fifteen years of the neuroendocrine control of lactation has made it possible to apply some of this information to the treatment of problems in lactation. Several CNS-active drugs have been used to inhibit lactation in man and animals, but few attempts have been made to increase milk production by neuroendocrine means [or by employing non-pharmacological management techniques that utilize the knowledge gained] (p 123).

D. THE PROBLEM

Concern about extending the duration of lactation has led public health agencies in several countries to initiate programs in support of breast feeding. Specific breastfeeding situations exist for which direct assistance with the milk-ejection reflex would be helpful. The physiology of lactation has been much researched. Little observational data or psychophysiological research exists, however, regarding what is going on during a feeding that would cue us in the application of the physiological data.

In view of the fact that the milk-ejection reflex (MER) is seen as critical in the maintenance of lactation, and since it is acknowledged to be inhibited by psychological stressors, a first step in psychophysiological research would appear to be the establishment of descriptive baseline data from a group of successfully nursing women. This descriptive data can be seen as prerequisite to subsequent research which might investigate the influences of awareness and self-regulation (that is, the potential for the adjunctive use of biofeedback) on this critical reflex. Can we describe more accurately just what is going on during a feeding? Can we observe repeatable phenomena? Can a "norm" or flow of events be described and measured more completely? Essentially then, this study will record peripheral physiological changes as they relate to stage of feeding in established lactation.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

A. CHAPTER OVERVIEW

Chapter two, "Review of the Related Literature", initially establishes the pragmatic context for this study. First discussed are Public health concerns about the duration of lactation. Next current knowledge regarding the maintenance of lactation, including the role of the milk-ejection reflex (MER) in galactopoiesis is examined and summarized. The chapter next examines the physiological sequences of the MER, in terms of pattern of oxytocin (OT) release, milk flow sequences, and peripheral cardiovascular effects. The psychological aspects of the MER, as well as the possibilities for central or peripheral inhibition, then leads into the psychophysiological rationale for this study and for the measures chosen. The chapter closes with a statement of the research questions suggested by the preceding discussion.

B. CONTEXT FOR THIS RESEARCH

Galactopoiesis: The Maintenance of Lactation

In recent years breastfeeding has seen a resurgence in popularity in western industrialized nations. More and more women are choosing to breastfeed their infants. Most successfully initiate breastfeeding, but many have difficulties maintaining lactation. In March 1981, 76.5% of all first-time mothers giving birth at three hospitals in Edmonton chose to breastfeed their babies. By the eighth week postpartum only 50% were still breastfeeding (Fieldhouse, 1984). Similar data have been reported for the rest of Canada (Ellis, 1986), for the United States (Feinstein, Berkelhamer, Gruska, Wong, and Carey, 1986; Martin, 1985; Martinez and Dodd, 1983), for Great Britain (Martin and Monk, 1982; Wright and Walker, 1983), and for Australia (Lumley, 1983; Palmer, 1984). Extending the duration of lactation is an objective promoted by the Canadian Pediatric Society (1978), and by Health and Welfare Canada which have recommended breastmilk as the principal source of nutrients for the first six months of life (Health and Welfare Canada 1979, 1986; Myres, Watson, and Harrison, 1981).

Attributing these reductions to "practical difficulties and frustrations", Fieldhouse (1984, p.132) emphasized the importance of continued support for the nursing mother. Support requires knowledge. The greater our knowledge of the typical sequences of lactation and of the physiological processes involved, the more able we will be to support and assist breastfeeding mothers in a variety of circumstances. Many aspects of breastfeeding have been researched in recent years, and various factors have been seen as contributing to difficulties in maintaining lactation. Most authorities have concluded that the milk-ejection reflex is a key aspect of the breastfeeding process, in that it affects milk production, mother-infant interaction, and mutual satisfaction during feeding (Ellis, 1986; Isbister, 1954; Lawrence, 1985; Martin, 1985; Neifert, 1983; Neville, 1983; Newton and Newton, 1950; Post and Singer, 1983; Riordan,1983; Woolridge, 1986).

To the casual observer, breastfeeding appears very similar to bottlefeeding. The infant sucks, and as a result of suckling obtains the milk. The breastfeeding sequence is, however, somewhat more complex than it appears. The baby sucks and gets that part of the milk stored in the lactiferous sinuses. The majority of the milk produced is unavailable to the baby or, in his

absence, to the breast pump via simple suction alone. Most of the milk is high up in the alveoli where it is made and from which it must be actively excreted or let-down by the mother. Most mothers can produce the milk, but if they are unable to excrete it, subsequent milk production is suppressed (Lawrence, 1980; Underwood and Hofvander, 1982). The quantity of milk produced is related to how thoroughly the breast was emptied at the preceding feeding. Although milk synthesis is continuous, most occurs during nursing or immediately thereafter (Jacobs and Daughaday, 1974). Continued incomplete excretion leads to a decreasing volume of milk being produced. If the infant is unable to suckle well, or if the milk-ejection reflex is not functioning adequately, incomplete milk removal results. Thus, the excretion of milk represents one of the critical aspects of the breastfeeding process. The mechanism of this excretion is the milk-ejection, or let-down, reflex.

The mother attempting to maintain a milk supply without vigorous suckling

With an adequately sucking baby and good technique, the milk-ejection reflex functions "synergistically" (Woolridge, 1986) with the baby's suckling to effect milk transfer and to maintain lactation. Some mothers,

however, are striving to establish or maintain a milk supply when they are separated from their infants (Stewart and Gaiser, 1978), and others are attempting to feed infants who are unable to suck vigorously due to illness (Bose, D'Ercole, Lester, Hunter, and Barrett, 1981; Osorio, Ferrari, Acland Ferrari, Suna, and Gerpe, 1981; Lawrence 1985), prematurity (Ruis, Rolland, Doesburg, Broeders, and Corbey, 1981), Down's syndrome (Aumonier and Cunninham, 1983), cleft lip or palate (Lawrence, 1985). Both these groups of women are attempting lactation with only minimal neural stimulation to initiate the sequence of milk-ejection.

Variability of the Milk-ejection reflex

For most women, milk-ejection has stabilized by approximately six weeks post-partum. However, the effectiveness and functioning of this reflex vary considerably.. Although, ideally, the letdown response becomes conditioned to the baby's sucking, by six weeks some mothers are identified as having difficulties, which are partly attributable to an insufficient let down.

Six weeks post partum marks the first complete medical check, after initial hospital release, for most babies, and some are identified at that time as not gaining sufficient weight. For many mothers

adjustments in technique and the routine management of breastfeeding (frequency and duration of feedings, proper positions for feeding) improve the milk supply. For some the baby's minimal weight gain becomes a first clue to physiological problems of mother (placental retention: Neifert, McDonough, and Neville, 1981; previous breast surgery: Farina, Newby, and Alani, 1980; insufficient glandular development: Neifert, Seacat, and Jobe 1985) or baby (gastrointestinal anomalies of the baby: Lawrence,1985; faulty sucking techniques: Marmet and Shell, 1984) which are contributing to an apparently limited milk supply and weight gain. Once both technique problems and physiological anomalies are ruled out, however, a group of women still remains whose babies' gain is still barely adequate.

Apparent failure to thrive can occur among breastfed babies (Davies and Evans, 1976; Clarke, Markanan, Griswold, & Mendoza, 1979; Evans and Davies, 1977; Roddey, Martin, Sweetenberg, 1981; O'Connor, 1978; Lawrence, 1981; Rowland, Zon, Lafleur, and Reiter, 1982; Davies, 1979). Failure to thrive is characterized clinically by the infant who continues to lose weight after 10 days of life, does not regain birth weight by 3 weeks of age, or gains at a rate below the 10th percentile for weight gain beyond one month of age

(Lawrence, 1985, p281). As Lawrence (1985, p.283) indicates, many possible causes must be considered when approaching the low weight-gain baby. Several factors may be involved, but after eliminating or identifying infant-related causes, inadequate functioning of the letdown reflex should always be considered. Cold or pain may interfere with the letdown, but the "most common cause of an inadequate letdown is psychological inhibition" (Lawrence, 1985, p. 288). Smoking may interfere with the let down, but research in this area seems preliminary and somewhat inconsistent. Weisberg's review article on smoking and reproductive health (1985) states that maternal smoking during pregnancy may lead to effects on lactation resulting from premature delivery, but otherwise does not address the issue. Andersen, Lund-Andersen, Larsen, Christensen, Legros, Louis, Angelo, and Molin (1982) found lower baseline prolactin levels among mothers who smoked compared to those who did not, but, relative to the current study, concluded that oxytocin function was independent of smoking.

In contrast, another group of women coping with "practical difficulties and frustrations", to which Fielding (1984) attributed termination of breastfeeding, represent an overactive letdown response. The cues

which distinguish the overactive letdown reflex syndrome (Andrusiak and Larose-Kuzenko, in press) include adequate, often rapid weight gain in the baby accompanied by a nursing behaviour pattern of fighting, struggling, and choking during feeding. When general development is normal and there are no apparent medical problems, the overactive letdown is described as "too much, too fast". The treatment, generally attempted through feeding management means, is the reduction of the strength of the letdown.

Despite the apparent and copious adequacy of the milk supply, the overactive letdown is often a cause of weaning because of the negative nursing experience for both the mother and baby.

In both these cases, the underactive and the overactive, the most common advice is to relax; for the underactive this is perhaps too general, and for the overactive perhaps inappropriate.

C. PHYSIOLOGICAL SEQUENCES OF THE MILK-EJECTION REFLEX (MER)

The Neurohormonal Sequence

The physiological sequences effecting the milk-ejection reflex have been widely researched, and the results reported in both the animal (Peaker, 1977; Cowie, 1972; Tindal, 1972; Lincoln and Paisley, 1982; Cleverley, 1968; Wakerley, Dyball, and Lincoln, 1972; Cross and Harris, 1952) and human literature (Tyson, 1977; Sala, 1964; Theobald, 1959; Tucker, 1979). Milk-ejection is a neurohormonal reflex (Folley, 1969), and, as such, involves both neural stimulation and endocrine response (Lawrence, 1980). Tactile stimulation of the nipple and areola stimulates the neural afferent pathway (Lawrence, 1980, identifies the supraclavicular nerves and the lateral and medial branches of the intercostal nerves; and Dawood, 1981, the third, fourth and fifth thoracic nerves) to the posterior pituitary. Vorherr (1974) described the anatomical pathway:

> Within the spinal cord the impulses are transmitted in spinothalamic tracts to the mesencephalon. In the mesencephalon the neural fibers bifurcate, and stimuli travel separately via different diencephalic routes to the hypothalamic areas involved with secretion and release of prolactin and oxytocin. . . . Afferent impulses

> reaching the paraventricular and supraoptic nuclei of the hypothalamus via the dorsal diencephalic route induce oxytocin synthesis and its secretion along neurosecretory axons into the posterior pituitary lobe for storage. Simultaneously, release of oxytocin from posterior pituitary neurovesicles is brought about by hypothalamic impulses travelling along secretory neurons of the hypothalamo-hypophysial tract to the posterior lobe. (p.130)

Thus, oxytocin (OT) is produced in the supraoptic and paraventricular nuclei of the hypothalamus (Verbalis and Robinson, 1985), and in response to stimulation from suckling is released from the posterior pituitary into the bloodstream. Upon reaching the breast, oxytocin produces contraction of the myoepithelial cells surrounding the alveoli which produce the milk. This contraction results in the milk being ejected from the alveoli, and literally being forced out of the breast. Initially this reflex response is erratic, that is, the response is not specific to the baby's sucking, and can be triggered by other stimuli. Gradually the letdown response becomes stabilized and focussed, until most of the time it is specific to the suckling to the baby.

Oxytocin and the Milk-ejection reflex

Oxytocin has been identified as the only known substance responsible for the let-down of milk (Vorherr, 1974, p.208), and studies have demonstrated that oxytocin is released selectively and discretely from anti-diuretic hormone (ADH, or vasopressin), the other hormone released by the posterior pituitary (Theobald, 1959; Cobo, DeBernard, Gaitlan, and Quintero, 1967; Bissett, Clark and Haldor, 1970; and Wakerley, Dyball and Lincoln, 1973 ; Johnston and Amico , 1986).

Milk flow studies

A significant group of studies has documented that breastmilk is excreted not in a long, slow, steady stream throughout a 10 -20 minute feeding as might be our perception based on bottle feeding. Noel, Suh, and Frantz (1974) documented milk being excreted prior to actual contact between baby and breast. Lucas, Lucas and Baum (1979) found, by weighing infants before and after feeding,that 50% of the milk was released by 2 minutes, and 80 - 90% by 4 minutes. Using an innovative nipple-shield sampling method, Lucas, Lucas and Baum (1980) confirmed their earlier data, reporting 80 - 90 % of the milk having been transferred in the first 4 minutes.

Oxytocin Flow

That oxytocin is released in an intermittent pulsatile fashion, rather than in a steady flow, has been documented by evidence from milk volume (Cobo, DeBernard, Gaitan, and Quintero, 1967; Tindal, 1972; Lucas, Drewett and Mitchell, 1980) and latterly from plasma levels of oxytocin itself (Dawood, Khan-Dawood, Wahi, and Fuchs, 1981; McNeilly, Robinson, Houston and Howie, 1983).

Patterns of oxytocin release are of significance in the context of the current study in that they influence temporal distinctions regarding discrete stages of feeding. Weitzman, Leake, Rubin, and Fisher (1980) found a significant increase in oxytocin by 3 minutes into a feeding and that the oxytocin level peaked at 6 minutes. Using careful serial sampling, Dawood., Khan-Dawood, Wahi, and Fuchs (1981) found a significant increase in circulating oxytocin in response to suckling, with the increase significant and most evident within the first 2 minutes of the feeding. Drewett, Bowen-Jones, and Dogterom (1982) found significant oxytocin increases during suckling when they compared the serum oxytocin levels measured during feeding with those taken from a control group who were lactating but not feeding during testing. McNeilly, Robinson, Houston, and Howie

(1983) found that an increase in oxytocin began before tactile stimulus. In this study the oxytocin response after suckling began was found to be more consistent at 4 and 11 weeks than in the immediate postpartum period. He also found no correlation between the amount of oxytocin released and the number of previous pregnancies. Johnston and Amico (1986) provided support for some of the sampling criteria in the current study. In a longitudinal prospective study of a group of mothers of mixed parity, Johnston and Amico (1986) found that in mothers giving no supplemental feeding to their infants oxytocin levels continued to increase between 6 weeks and 6 months. (This is in contrast to Prolactin levels which peaked and then subsided once lactation was established.) They confirmed the independent release of Oxytocin and ADH; and, in addition, found no diurnal variation in the pattern of Oxytocin release, thus providing the rationale for data collection at different times of the day).

Oxytocin and Cardiovascular Effects

Anecdotal evidence for the cardiovascular effects of oxytocin has come from the many mothers who describe warm hands and an upper body flush of warmth concurrent with the sensation of the milk letting down.

Reviewing the cardiovascular actions of oxytocin, Nakano (1973) felt that the principal circulatory effects of oxytocin occurred in the peripheral blood vessels. The vessels of the skin were very sensitive to the vasodilator action of oxytocin, and oxytocin was found to "dilate the vascular beds in the extremities and increases the blood flow without increasing systemic arterial pressure" (Nakano.,1973, p.73). Interestingly, among its effects, oxytocin was found to modulate the cardiovascular actions of the catecholamines

The vasodilatory effects of oxytocin have been demonstrated when the hormone has been experimentally injected. Kitchin, Lloyd and Pickford (1959) found that oxytocin had a vasodilatory action to which the hand was more resonsive than the forearm. Greenfield (1962) describes blood flow through the hand doubling for a few minutes following injection of oxytocin into the brachial artery. Haigh, Kitchin and Pickford (1963) showed that intra-arterial injection of

even small amounts of oxytocin increased the blood flow in the hand on the side of the injection. Deis, Kitchin and Pickford (1963) described increased cutaneous blood flow as a characteristic of higher doses of oxytocin.

Some preliminary research has been done on the possibility of a relationship between vasodilation and lactation. Abolins (1954) measured the temperature of mammary skin before and after feeding and found that there was a strong positive correlation between milk volume and a rising or stationary high temperature. Using infrared thermography, Lind, Vuorenkoski, and Wasz-Hockert (1972) documented a significant increase in breast warmth when the milk ejection reflex ocurred in response to the sound of a crying baby. Jelliffe and Jelliffe (1978) felt that the temperature increases reported by Lind et. al. were the result of increased blood flow to the skin covering the breast. Initial attempts have been made to document temperature change during feeding. In a single subject case study which involved informal temperature recording, Walker (1981) observed finger temperature increase during breastfeeding.

Implications for the current study

Given the parallel temporal sequences of significant milk flow and oxytocin increase it seems reasonable to divide feedings into three significant time periods: the period when feeding is being initiated, but prior to contact; the period which ends two minutes after feeding is in initiated; and the period which ends five minutes after feeding is initiated. In addition, given the cardiovascular effects of oxytocin documented in the literature, it may be possible to explore a possible relationship between finger temperature and oxytocin release during feeding given this temporal sequencing.

D. PSYCHOLOGICAL ASPECTS OF MILK-EJECTION

The psychological influences on this neuro-hormonal reflex have been considered by a number of researchers. Martin (1986) discussed the relationship between maternal anxiety and breastfeeding. Zichella (1975) argues the necessity for research into the psychoneuroendocrine aspects of lactation. Newton (1978) speculates that "oxytocin-related interpersonal reproductive acts may create pair-bonding"(p.416). Vorherr (1971) suggested that lactation difficulties are frequently the result of hyperfunction of the

sympathetico-adrenal system. Newton and Newton (1967) describe the letdown reflex as a psychosomatic mediating mechanism i.e. "the route by which emotional and psychosocial factors influence milk production" (p.84).

Sympathetic Arousal/ANS

The autonomic nervous system functions to control the internal environment of the body. As such, a balance is maintained between the sympathetic and parasympathetic divisions of the autonomic nervous system. Increased physiological arousal triggers a shift toward sympathetic functioning, and reduced arousal brings a shift toward greater parasympathetic functioning. Cannon (1932) introduced the term "homeostasis" to describe this shifting inner balance.

Opposing innervations from the sympathetic and parasympathetic divisions permit prompt, precise regulation. The nerve fibers of the autonomic nervous system are described as being either pre-ganglionic or post-ganglionic. Pre-ganglionic fibres run from the spinal cord to the sympathetic ganglia (some pre-ganglionic sympathetic fibres synapse in the adrenal medulla, rather than in the ganglia). Post-ganglionic

fibres run from the ganglia to their effector organs. The neurotransmitter for the preganglionic synapses of both the sympathetic and parasympathetic divisions is acetylcholine. The neurotransmitter for the post-ganglionic sympathetic synapses is norepinephrine, and for the parasympathetic is acetylcholine. The adrenal medulla parallels the postganglionic sympathetic synapses, but releases epinephrine rather than norepinephrine. (Lamb, Ingram, Johnston, and Pitman, 1984).

Two types of receptors are stimulated by the sympathetic postganglionic system, and which have opposite reactions. Alpha adrenergic receptor sites are associated with functions which are inhibited during sympathetic arousal, for example the constriction of the peripheral blood vessels of the skin. Beta adrenergic receptor sites are associated with functions which are stimulated during sympathetic arousal (Van Toller, 1979).

Sympathetic Arousal relative to lactation: Inhibition of the milk-ejection reflex

Using a combination of observable clinical symptoms and an objective test of the let-down, Newton and Newton (1950) concluded that the reflex functioned erratically in those women who were unsuccessful at breastfeeding. Michael Newton (1961) indicated that the most obvious result of failure of the milk ejection reflex is "that although the breasts may be full of milk the baby is unable to obtain more than a small amount. This then leads to less sucking stimulation, and eventually failure of lactation" (p. 305). Through distractive techniques that did not appear to disturb the baby, Newton and Newton (1948) experimentally inhibited the letdown reflex. They concluded that milk ejection is "very sensitive to small differences in oxytocin level, suggesting that minor psychosomatic changes may influence the degree to which milk is available to the baby" (1967, p.85).

Peaker (1976) noted that stress and subsequent sympathetic arousal reduces blood flow in the breast and lowers the rate of milk secretion because the the blood vessels of the breast are extremely sensitive to the vasoconstrictive action of epinephrine and norephrine.

Central versus Peripheral inhibition

Whether milk-ejection is inhibited at a peripheral or central level has been the subject of much research. Lefcourt and Akers (1984), Bisset, Clark, and Lewis (1967), Gorewit and Aromando (1985), Chan (1965), and Tyson (1977) advocate peripheral inhibition. Because the adrenaline induced inhibition of the MER was abolished by beta-blockers, Bisset, Clark, and Lewis (1967) concluded that there are beta-adrenergic receptor sites in the breast which mediate the inhibitory action of adrenaline. In contrast, other researchers are convinced a central mechanism is involved (Newton and Newton, 1948; Cross, 1955 & 1974; Summerlee, O'Byrne, Paisley, Breeze, and Porter, 1984 ; Aulsebrook and Holland, 1969; Moos and Richard, 1979; Lincoln and Paisley, 1982). Cross, for example, reports "adrenaline as an important inhibitory neurotransmitter for . . . oxytocinergic cells [in the hypothalamus] " (1974, p 40). Vorherr (1971) and Tindal (1962) feel that both central and peripheral mechanisms may be involved.

Gorewit and Aromando (1985) summarize the various arguments. There are four possible mechanisms for the stress-related inhibition of the milk-ejection reflex: inhibition of the neurosecretory hypothalamic cells (Moos and Richard, 1979; Lincoln and Paisley, 1982);

inhibition of oxytocin release within the posterior pituitary (Cross, 1955); reduction of blood flow in response to sympathetic arousal preventing oxytocin from reaching the myoepithelial receptor sites in the breast (Gorewit and Aromando, 1985; Vorherr, 1971); stimulation of mammary myoepithelial beta receptors resulting in reduced sensitivity to oxytocin (Chan, 1965; Bissett, 1967; Tyson, 1977). Vorherr takes the position that inhibition is 30-40% the result of reduced blood flow, 50% the result of reduced myoepithelial sensitivity. Tindal (1977) desribes both central blockade of the release of oxytocin, and peripheral vasoconstriction at the breast resulting in oxytocin not reaching the myoepithelial cells in a threshold amount. Whatever the ultimate consensus, and the literature seems divided, the research together suggests a system very sensitive to adrenergic inhibition at both central and peripheral levels.

E. PSYCHOPHYSIOLOGY

Psychophysiological Research

Working from the perspective of psychophysiology, a research study will manipulate a psychological variable (emotional, cognitive, or behavioural) and then record the

physiological response. In terms of this study the behaviour manipulated is the initiation of a feeding, followed by the feeding itself, and the physiological responses being recorded (finger temperature, skin conductance response, breast temperature) were chosen according to the criteria established by Feuerstein Labbe, and Kuczmierczk (l986).

Significance of the Physiological Measures Chosen

Feuerstein, Labbe, and Kuczmierczyk (l986, p 60) suggest three assumptions which should be met by physiological measures chosen (in this study, as responses monitored to determine activity in the CNS/ANS/endocrine systems). These assumptions relate to the theoretical significance of the chosen response(s):

1. Their significance in the etiology ,exacerbation, or maintenance of some illness or dysfunction: in this study, sympathetic arousal in the inhibition of the letdown;

2. Their significance as a representative measure of some biological activity: in this study, as a general index of sympathetic activity (and, hypothetically from the cardiovascular literature, of oxytocin);

3. Their significance as indicative of a specific end-organ response which is important in understanding some psychobiological process: in this study, vasoconstriction/ dilation at the breast as these have an applied significance relative to peripheral inhibition of the milk-ejection reflex.

Taylor and Epstein's "Measurement of Autonomic Arousal" (1967) also provided some of the rationale for the approach undertaken in this study. Physiology has documented the neuro-endocrine sequences in lactation and has pointed up the sensitivity of this function/process to physical and emotional stressors. Psychologists have looked at the relationship (Newton, 1977). The medical perspective has considered other aspects of the process. Some attention has been paid in comparative studies of lactation to the specifics of sympathetic arousal as it influences lactation (Cross, 1955). On the whole, however, little effort has been made to integrate these various theoretical , and applied levels of information. Taylor and Epstein suggest "learning more about the unique properties of the different physiological systems, and thereby selecting a measure well-suited to the particular conditions being investigated " (p. 523). They also suggest that "the solution to the measurement of general arousal and the

selection of physiological measures [will be found] in determining the unique properties of physiological systems as they relate to the parameters of stimulus input" (p524). Thus, one would not use hand temperature as a measure of general arousal, if this were to the exclusion of its significance relative to the physiological system relevat to the study in question. They, therefore, advocate the selection of hand temperature as a measure especially "suited to the particular conditions being investigated " (p. 523).

Schneider (1976) suggested that if the researcher's objective is the measurement of sympathetic arousal, then the best sites would be those that receive only sympathetic innervation (in contrast to most systems/organs that receive both sympathetic and parasympathetic innervation). Schneider (1976) cites several researchers (Gaskell, 1956; Warren, Walter, Romano & Stead, 1942; Roddie, Shepherd & Whelan, 1957) in support of his position that the "underlying process for fluctuations in skin conductance, and for hand, finger and toe blood flow is considered to be exclusively a function of the sympathetic division of the autonomic nervous system" (p 144). Feuerstein, Labbe and Kuczmierczyk (1986) take the same position regarding sympathetic innervation to the vessels of the hands and

toes (p. 65). Vorherr(1977) documents the breast as also having no parasympathetic innervation.

The Measures Chosen

Finger temperature

The relationship between finger temperature and sympathetic arousal is articulated by Ganong (1979), who attributes the constriction of cutaneous blood vessels to adrenergic nerve stimulation and to circulating epinephrine and norepinehrine. Vasodilation is brought about by decreasing constriction since there are no known vasodilator neural fibres to the blood vessels of the skin. Casper, Yen, and Wilkes operated under the premise that the vessels of the fingers are under the exclusive control of an alpha-adrenergic vasoconstriction mechanism, and cited Greenfield (1962).

Relative to this study, and in light of the evidence in the literature regarding the peripheral cardiovascular effects of oxytocin, one would expect that changes in finger temperature during breastfeeding would be observed. To date this does not seem to have been demonstrated. If injected oxytocin raises finger temperature, can we then infer that finger temperature increases (at a stage of feeding when oxytocin has been

documented) can be attributed to oxytocin? Evidence for the possibility of an endocrine cause or control mechanism for fingertip temperature changes is supported by Casper, Yen and Wilkes (1979) who found that circulating catecholamine concentrations did not change during menopausal flush episodes and concluded, therefore, that a peripheral mechanism is probably not causally involved. They did, however, conclude that central neuroendocrine mechanisms initiated the temperature changes.

Skin Conductance Response

Skin conductance level refers to the "electrical conductivity of the skin with respect to a constant voltage applied to its surface [and refers to] momentary, relatively rapid fluctuations in skin conductance level as a result of situational psychophysiological responses to discrete stimuli" (Wilkinson, 1976, p82). This electrical conductivity is measured is micromho, and is the reciprocal of skin resistance which is measured in ohms. The skin conductance response (SCR) represents a positive linear relationship between conductance level and level of sympathetic arousal.

Greenfield and Sternbach (1972, p 401) described thesignificance of the SCR as a psychophysiological

measure in terms of its behavioural correlates and applications: "the most direct interpretation of the electrical behaviour of the skin appears to be in its reflection of the sympathetic inflow to the cutaneous area under observation." Feuerstein, Labbe, and Kuczmierczyk (1986) describe the electrodermal response [including the SCR] as a " unidirectional index of sympathetic arousal of excitation; as arousal increases [the SCR as a] measure of electrodermal activity also increases "(p 65). They go on to describe the eccrine sweat glands as being exclusively innervated by sympathetic postganglionic fibers. Geddes and Baker (1975) elaborate the point further, stating that the SCR requires the presence of active sweat glands which in humans are activated via the sympathetic nervous system by acetylcholine.

Relative to this study, the SCR would thus seem ideally suited as a measure of sympathetic arousal which may be independent of the possible effects of circulating oxytocin, and which, given its cholinergic innervation, may also be independent of epinephrine levels. Therefore the SCR may suggest levels of sympathetic arousal if finger temperature/vasodilation is being influenced by possible oxytocin level changes.

Breast temperature

As indicated previously, research has linked heightened sympathetic arousal and reduced milk excretion. Vorherr (1974) articulated the functional sequences related to sympathetic arousal and milk-ejection. There is no innervation of the the mammary myo-epithelial cells, therefore let-down activity is independent of nervous stimulation, and results from the effects of circulating hormones. Given mammary stimulation, postganglionic norepinephrine is released causing contraction of smooth muscle in the areola and the mammary blood vessels. "Because there are no para-sympathetic fibers present in the mammary glands neither vascular nor myoepithelial smooth muscle stimulation [i.e. vasodilation and myoepithelial contraction, respectively] due to postganglionic acetylcholine release is observed" (p35).

In view of the supportive evidence from physiological research and previous research results specific to lactation (Abolins,1954; Lind et al, 1972; and Walker, 1981) the measurement of breast temperature may replicate previous results. Data collection in a natural setting with methodologically controlled conditions (with systematic recording, and with mother and infant not separated), may extend the existing results.

F. HYPOTHESES AND RESEARCH QUESTIONS

Exploratory Research

Kerlinger (1986) describes an exploratory study as one which "seeks what is, rather than predicts relations to be found" (p.373). Its purposes include the following:

1. to discover significant variables in the natural setting/field situation
2. to discover relations among variables
3. to lay the groundwork for later testing of hypotheses. (1986, p.373)

In terms of this study, this translates to conducting a preliminary methodological and measurement investigation in order to establish the variables, and describe physiological changes during lactation as these relate to behavioural sequences.

Hypotheses

A number of repeated observations are suggested by the preceding discussion of the literature. The basic objective of this study is to record responses at different stages of feeding, particularly as these intersect with the timing of the MER and of OT flow as reported in the literature; thus the following null hypotheses.

1. There will be no difference in finger temperature when observed at the following stages of feeding: Baseline, Volition, Two Minutes, Five Minutes.

2. There will be no difference in skin conductance response when observed at the following stages of feeding: Baseline, Volition, Two Minutes, Five Minutes.

3. There will be no difference in breast temperature when observed at the following stage of feeding: Baseline, Volition, Two Minutes, Five Minutes.

CHAPTER THREE

DESIGN AND PROCEDURE

A. CHAPTER OVERVIEW

Chapter three, "Design and Procedure" reviews the experimental procedures employed in the study.

B. SAMPLE

Twenty-six women who were breastfeeding infants were selected from those who volunteered for this study. Mothers were selected from responses to a request for volunteers that was made to the Greater Edmonton Birth and Parent Education Centre, the La Leche League, two day care centers, and several church groups in the greater Edmonton area. All infants were more than six weeks but less than six months old, and none were yet on solid foods nor being supplemented with formula. All of the infants were full term and had been gaining an average of 4-6 ounces per week since birth. The mothers were of mixed parity, and all but one were non-smokers. All of the mothers had had post-partum obstetrical examinations with no apparent placental retention. None of the mothers had resumed menstruation. These criteria were confirmed during an initial interview with

each mother, and following a standard interview checklist (see Appendix A).

C. PROCEDURE

The methodology used in this study was developed in an attempt to take into consideration possible confounding variables suggested in the psychophysiological and biofeedback literature. Broder (1979) stressed the importance of achieving a baseline period long enough to permit responses to stabilize once the sensors have been attached. Yates (1980) suggested a similar adaptation period in order to adjust from outside temperatures and/or varying levels of activity prior to the recording session. Control of ambient temperature in the recording setting is recommended by several researchers (King and Montgomery, 1980), with Broder (1979) specifying a range of 70° to 72° Fahrenheit.

Most breastfed babies in this age range feed every two to three hours. Consequently, subjects were invited to arrive at the research setting approximately 1 1/2 hours after a feeding and to plan to spend an hour, to an hour and a half. Allowing 20 minutes adaptation time (to ambient temperature and the presence of the sensors), 1 1/2 hours postfeeding was considered the

latest possible arrival time. It was hoped that the extended period in the research setting would reduce possible performance stress by creating a time span during which the baby would be willing to feed without the mother having to initiate a feeding or being concerned that the baby might not be willing. The majority of oxytocin-lactation studies have been hospital-based early post-partum observations. These would appear to be potentially confounded by the separation of mother and baby in most hospital settings. When separated from the baby, the mother is more apt to respond to crying or to sounds of the baby coming from the nursery -- and this anticipation is in part responsible for preliminary oxytocin release. An attempt was made to control for this by using the adaptation period as a time when mother and baby are calmly together, thus establishing the baseline temperature in a calm non-feeding, but not separated situation.

The experimental room was furnished for a non-clinical appearance, with pictures, plants, rug, etc. Ambient room temperature remained 70° - 72° F. throughout the experiment. Subjects were seated in a comfortable chair with arms. Subjects were provided with a short sleeved, scooped-neck, loose fitting T-shirt (60% polyester, 40% cotton) which permitted easy

placement of the recording thermistors, and made it possible to fasten the various wires out of the way of both mother and infant.

After seating, one thermistor was attached to the outer surface of the middle phalange of the third finger of the hand holding the baby. This hand was chosen because of its accessibility during feeding, and because for most mothers, this is the less active hand during feeding.

The thermistor measuring breast temperature was placed at approximately a 45 angle on the upper inside quadrant of the breast from which the baby would first feed (at approximately 2 o'clock when facing the mother). Placement was at a distance from the edge of the areola equal to approximately the radius measurement of the areola. Rationale for this placement is based on Lind's thermography study (1972) which showed this as an area of the breast in which substantial temperature increase occurs. Additional rationale is provided by Lawrence's description (1980) of the major (60%) blood supply to the breast being supplied by the anterior perforating branches of the internal mammary artery. More pragmatically, this placement leaves the thermistor out of the way of both the infant and the mother's arm when the baby is in a transverse feeding

position; and, further, utilizes that part of the breast for which there is the least variability in individual shape.

The sensors recording skin conductance response (SCR) were placed on the fleshy area of the palm just below the base of the fingers on the same hand from which temperature readings were being taken. The sensors were held in place by a rigid band (3" x 1") of velcro sensitive material, and which was attached to the hand by a velcro band around the palm and knuckles. Interference from the wires attached to the sensors was minimized by having them pass between her fingers. This placement site and arrangement of the wires permitted the mother to use the heel of her hand to support the baby without contact being made between the baby and the sensors.

After the sensors were in place, and while the mother was adapting to their presence and to ambient room temperature, background information was obtained in a conversational format using a standard checklist (see Appendix A). Approximately 15 minutes later, recording of baseline readings was begun by starting a stop watch and initiating a biocomp recording session. After five minutes of baseline recording the mother was asked if she thought the baby might be willing, and in response to

a volitional act to initiate the feeding (by arranging her clothing to place the baby at the breast) the time was recorded using a lap-time stop watch. Two minutes following the mother's volitional act to initiate feeding, a second time was marked, since this is the time by which most researchers have reported the milk-ejection reflex to have occurred (Janbu, 1985; Dawood, 1981). Additional recordings were compared at five minutes in order to record possible changes occurring as a result of the subsequent pulsatile excretion of oxytocin documented by Dawood (1981). Although many of the infants suckled for less than ten minutes, recording continued for a maximum of 20 minutes after the baseline period. If the baby was unwilling to suckle for the entire period, recording was terminated when suckling ended, and this was recorded with the data.

Once feeding was completed on the first breast, the thermistors were removed to permit the mother to care for the infant. Additional recordings were not made during feeding at the second breast since not all infants were willing to feed again on the second side, and because research data suggests that a second reflex does not always occur during sucking at the second breast (Janbu, 1985). Once the baby's needs had been attended to, the mother was then shown the recording

from her session, and a debriefing explanation was provided.

D. INSTRUMENTATION

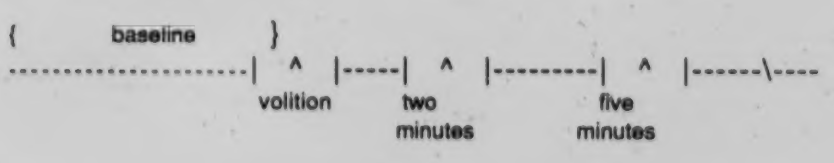
The Biocomp 2001 was used to record finger temperature, skin conductance response, and breast temperature. Manufactured by the Biofeedback Research Institute of Los Angeles, California, the Biocomp is a computer program used to guide the Apple IIe. Simultaneous recording from three modalities are transferred via phototelemetry units to the Apple IIe, where they were stored and graphed.

The Biocomp permitted simultaneous recording of data for each of the three sensors being used in this study (peripheral finger temperature in degrees Fahrenheit, peripheral breast temperature in degrees Fahrenheit, and skin conductance response in micro-mhos) The Biocomp was set up to record continuously, with thirty-two 25-second observation units during the baseline and feeding period. Each of these data points reflects the averaged value of the continuous readings made during the preceding 25 second period. Recording of baseline readings began after a minimum twenty minute adaptation period during which the sensors were in place. Baseline levels of each modality refer to the mean

value over the baseline period. The second stage of feeding (volition) refers to the moment at which the mother initiated feeding and represents an observed behavior. The third stage of feeding (two minutes) refers to the data point two minutes following volition. The third stage of feeding (5 minutes) refers to the data point five minutes following volition.

Figure 1

DATA RECORDING POINTS AS THEY REFLECT STAGE OF FEEDING



CHAPTER FOUR

RESULTS

A. CHAPTER OVERVIEW

Chapter 4, "Results", includes a description of the data recorded at each stage of feeding for each physiological measure, a restatement of the hypotheses presented in Chapter 2, and a presentation of the findings and conclusions related to these hypotheses.

B. DESCRIPTIVE DATA

Before testing the hypotheses, a summary of the values at each stage of feeding will be made for each measure.

Baseline Data

Table 1 shows the means and standard deviations of the baseline scores for each of the three physiological measures, together with their minimum values, maximum values and range. It can be observed that the group's mean baseline finger temperature was 89.13° F, and ranged from 81.93° F to 93.31° F. SCR responses ranged from 3.14 to 25.47 micromho, with a mean value of 15.51. Breast temperature ranged from 91.75° F to 96.73° F, with the mean temperature being 94.4° F.

TABLE 1

SUMMARY OF BASELINE DATA

N=20

MEASURE	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
1. Finger Temp (degrees F)	89.13	3.19	81.93	93.31	11.38
2. S C R (micromho)	15.51	6.65	3.14	25.47	22.33
3. Breast Temp (degrees F)	94.43	1.42	91.75	96.73	4.98

TABLE 2

FINGER TEMPERATURE IN DEGREES FAHRENHEIT

AT EACH STAGE OF FEEDING

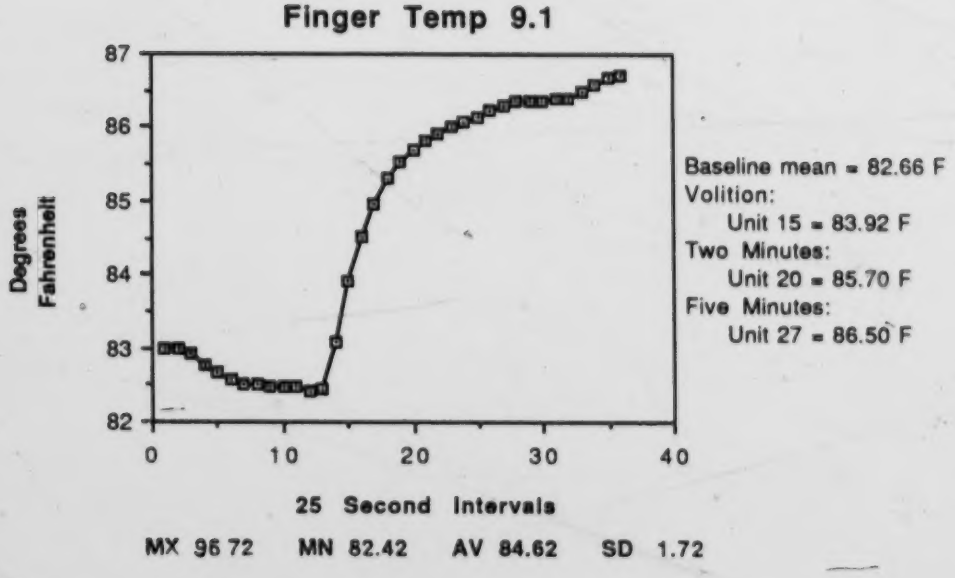
N=20

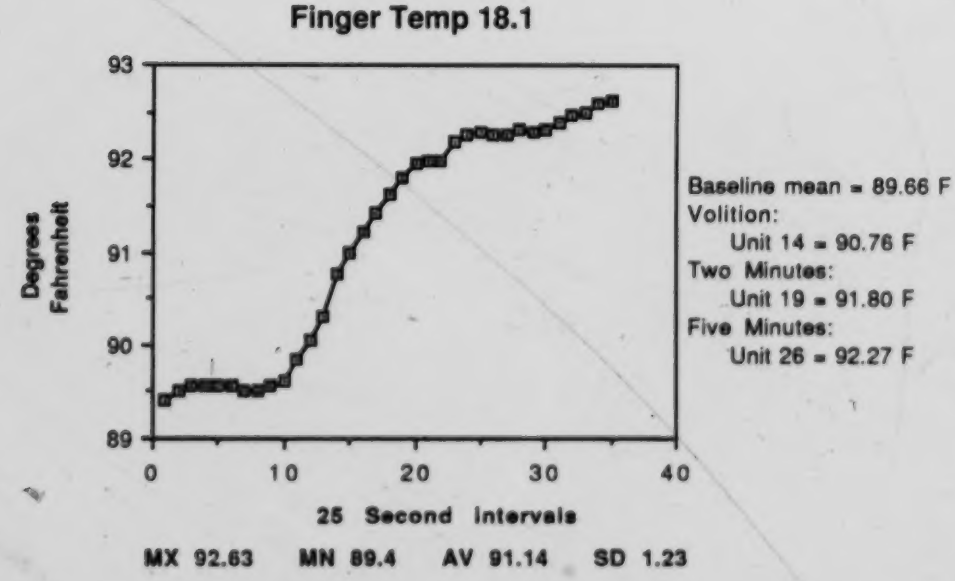
STAGE OF FEEDING	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
1. Baseline (T1)	89.13	3.19	81.93	93.31	11.38
2. Volition (T2)	89.85	3.31	82.11	94.31	12.2
3. Two minutes (T3)	91.32	3.44	82.47	95.31	12.84
4. Five minutes (T4)	91.45	3.13	84.6	95.76	11.16

Finger Temperature Data

Table 2 shows the mean value, standard deviation, maximum and minimum values, and range at each stage of feeding for finger temperature. Mean finger temperature increased from a baseline reading of 89.13° F to 89.85° F at volition, to 91.32° F at two minutes, and 91.45° F at 5 minutes. The average increases relative to baseline were .72° F at volition, 2.19° F at two minutes, and 2.3° F at five minutes. The greatest temperature changes, relative to baseline, which any mother showed were 1.93° F at volition, 4.97° F at two minutes, and 5.96° F at five minutes. Figure 2 displays sample data files for Finger Temperature from two of the mothers in the study. Figure 3 displays the mean finger temperature values for the sample at each stage of feeding.

Figure 2. Sample data files: finger temperature





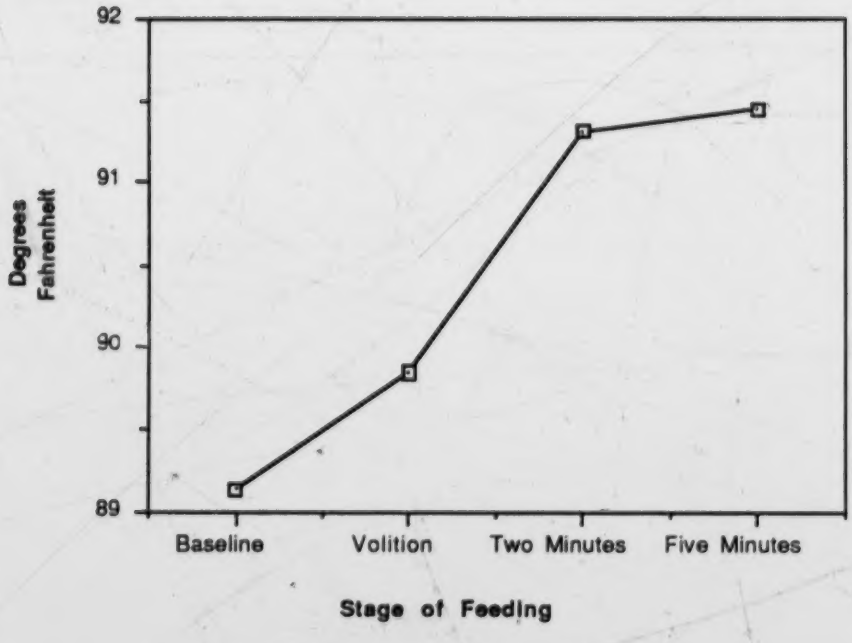


Figure 3.
Mean finger temperature at four observed stages of feeding

Skin Conductance Response Data

Table 3 shows the mean value, standard deviation, maximum and minimum values, and range at each stage of feeding for the skin conductance response. Mean SCR values changed from a baseline reading of 15.51 micromho, to 19.27 micromho at volition, to 16.74 micromho at two minutes, and to 15.86 at five minutes. Sample data files for the SCR readings of two mothers are displayed in Figure 4. Figure 5 displays the mean values for this measure at each stage.

TABLE 3

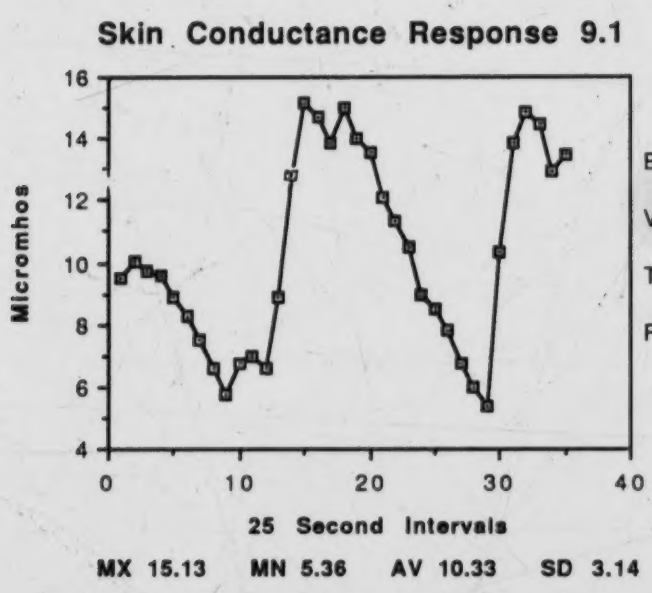
SKIN CONDUCTANCE RESPONSE IN MICROMHO

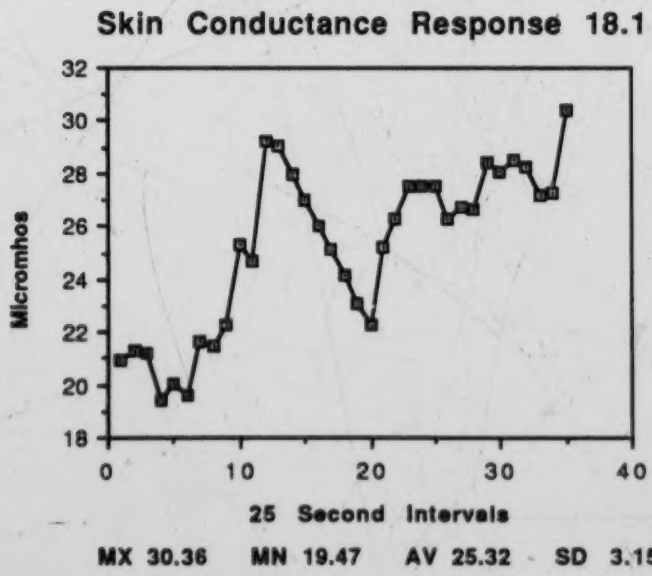
AT EACH STAGE OF FEEDING

N=20

STAGE OF FEEDING	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
1. Baseline (T1)	15.51	6.65	3.14	25.47	22.33
2. Volition (T2)	19.27	6.84	8.1	32.72	24.62
3. Two minutes (T3)	16.74	7.04	3.56	25.98	22.42
4. Five minutes (T4)	15.86	7.25	2.12	26.27	24.15

Figure 4. Sample data files: skin conductance response





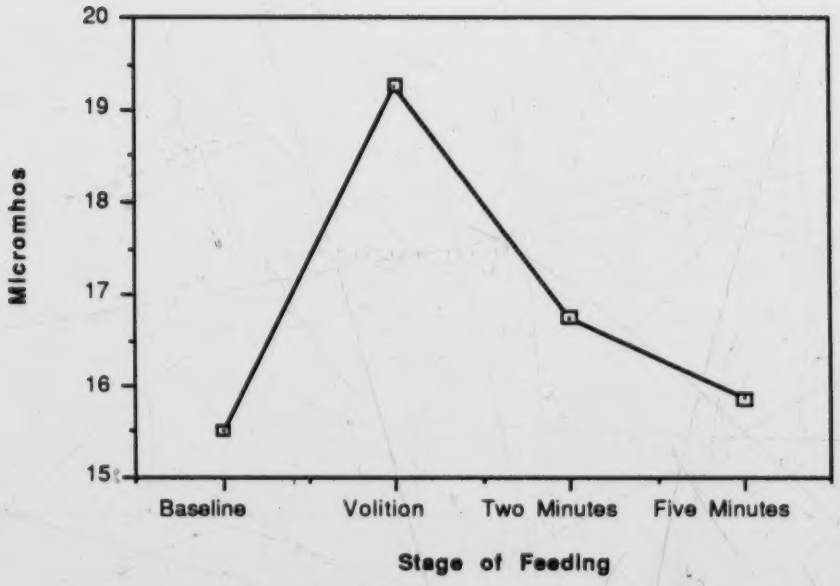


Figure 5.
Mean skin conductance response (SCR) at four observed stages of feeding

Breast Temperature Data

Table 4 shows the mean value, standard deviation, maximum and minimum values and range at each stage of feeding for breast temperature. Mean breast temperature increased from a baseline reading of 94.43° F, to 95.12° F at volition, to 95.80° F at two minutes, and to 95.83° F at five minutes. (*Note Table 4: One mother's breast temperature climbed to 98.76° F by five minutes. She reported feeling very warm since her baby's birth.) Once again, sample data files for breast temperature are displayed in Figure 6. Figure 7 displays the mean values for this measure at each stage of feeding.

TABLE 4

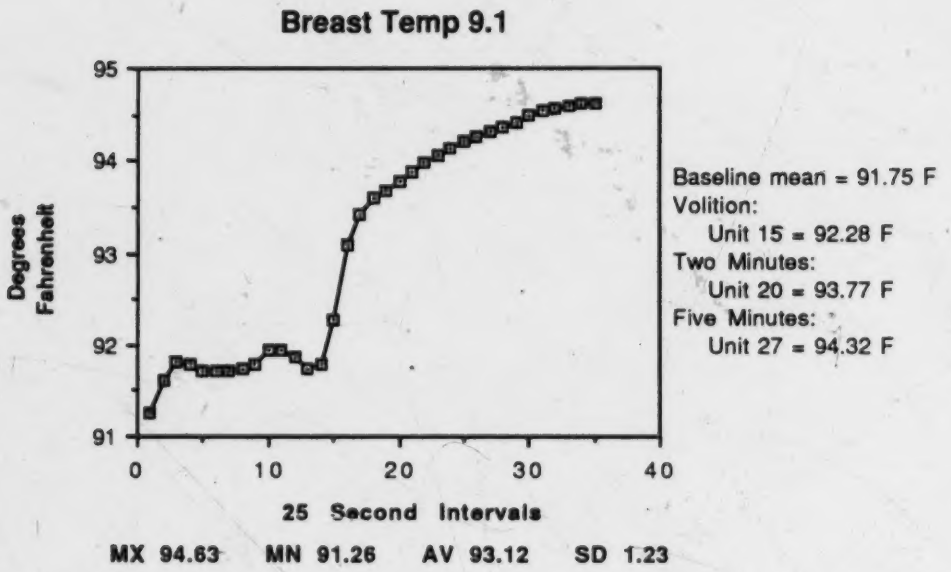
BREAST TEMPERATURE IN DEGREES FAHRENHEIT

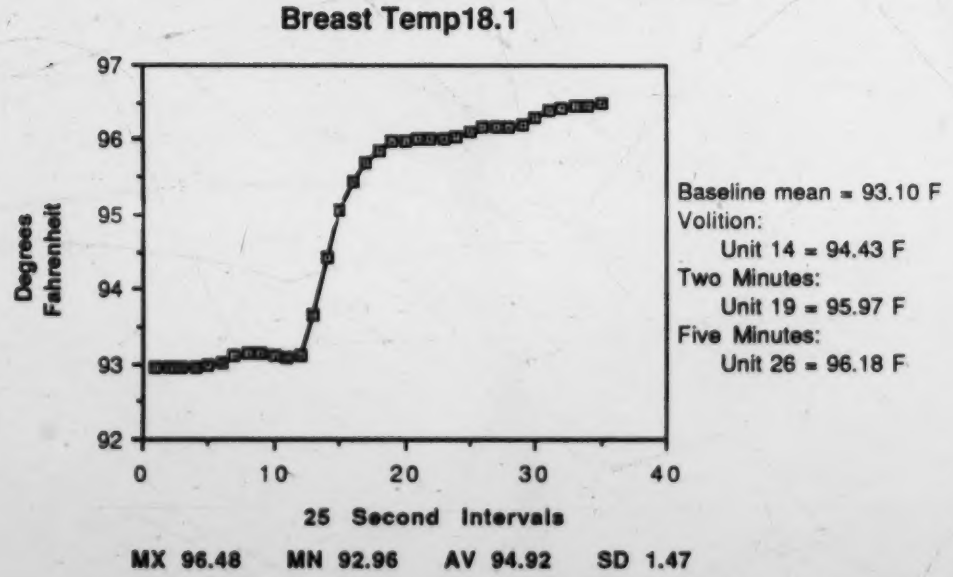
AT EACH STAGE OF FEEDING

N=20

STAGE OF FEEDING	MEAN	S.D.	MINIMUM	MAXIMUM	RANGE
1. Baseline (T1)	94.43	1.42	91.75	96.73	4.98
2. Volition (T2)	95.12	1.32	92.28	97.22	4.94
3. Two minutes (T3)	95.80	1.68	91.62	98.37	6.75
4. Five minutes (T4)	95.83	2.05	89.45	98.76*	9.31

Figure 6. Sample data files: breast temperature





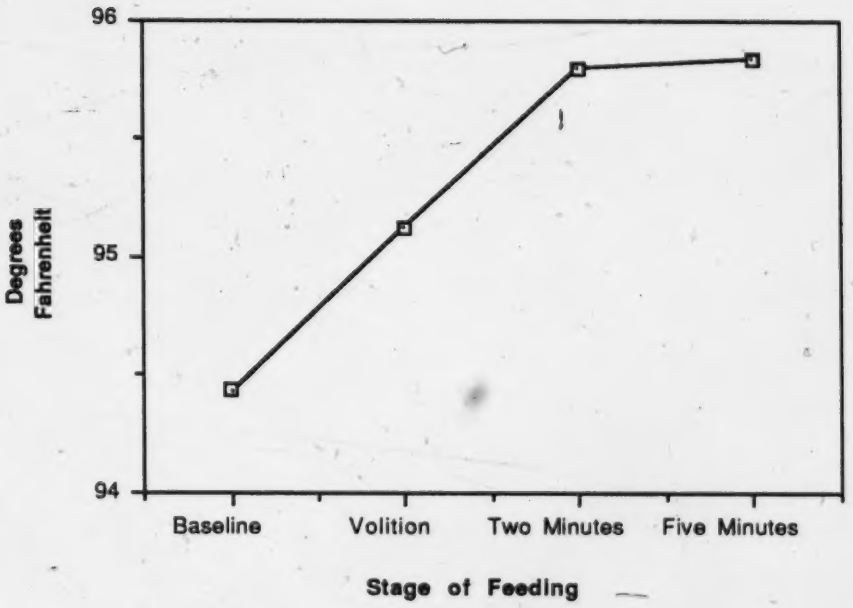


Figure 7.
Mean breast temperature at four observed stages of feeding

C. HYPOTHESIS TESTING

In order to test the hypothesized effects of stage of feeding on each of the peripheral physiological measures, a one-way repeated measures ANOVA (Kerlinger 1986, p. 331; Jaccard, 1983, p. 240-246) and the Scheffe test (Kerlinger 1986, pp. 218-219) were applied to the data for each measure.

HYPOTHESIS 1

There will be no difference in finger temperature when observed at the following stage of feeding: Baseline, Volition, Two Minutes, and Five Minutes.

Findings

Table 5 presents the summary table for the analysis of variance performed relating stage of feeding and finger temperature. The observed F ratio was statistically significant ($F = 31.78$, $p < .0001$). The strength of the relationship was calculated using eta squared, which showed that after the effects of individual background had been removed, 86% of the variability in finger temperature was associated with stage of feeding. Given the significance of the F ratio, Scheffe tests were performed in order to contrast the mean values at different stages of feeding when these were paired for comparison purposes. The results of the Scheffe tests are presented in Table 6.

Referring to Table 2, finger temperature increased at each stage of feeding. Table 6 illustrates that after Scheffe tests were performed finger temperature was found to be significantly ($p>.05$) higher than baseline at Two Minutes ($F= 19.74$), and at Five Minutes ($F=22.15$), and was significantly higher than Volition at Two Minutes ($F = 8.91$) and at Five Minutes ($F = 10.55$). There were no significant difference between Baseline and Volition, nor between Two Minutes and Five Minutes.

Conclusion

This analysis rejects the null hypothesis. Finger temperature increased in relation to stage of feeding. Significant increases in finger temperature occurred, relative to Baseline and to Volition, at Two Minutes and Five Minutes.

TABLE 5
ANALYSIS OF VARIANCE : FINGER TEMPERATURE
N=20

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F
Between Subjects	65.75	19	40.30	19.66
Within Subjects	123.01	60	2.05	
treatments	76.99	3	25.6	31.78
residual	46.03	57	8.08	
Total	888.77	79		

TABLE 6

SUMMARY OF DIFFERENCES BETWEEN

PAIRED STAGE OF FEEDING MEANS : FINGER TEMPERATURE

COMPARISON	MEAN DIFFERENCE	SCHEFFE
Baseline vs Volition	-.718	2.125
Baseline vs Two Minutes	-2.19	19.74*
Baseline vs Five Minutes	-2.32	22.15*
Volition vs Two Minutes	-1.47	8.91*
Volition vs Five Minutes	-1.56	10.55*
Two Minutes vs Five Minutes	-.13	.069

*Significant at 95%

HYPOTHESIS 2

There will be no difference in skin conductance response when observed at the following stages of feeding: Baseline, Volition, Two Minutes and Five Minutes.

Findings

Table 7 presents the summary table for the analysis of variance performed relating stage of feeding and skin conductance response. The observed F ratio was statistically significant ($F = 5.178$, $p < .0031$). The strength of the relationship was calculated using eta squared, which showed that after the effects of individual background had been removed, 79% of the variability in skin conductance response was associated with stage of feeding. Given the significance of the F ratio, Scheffe tests were performed in order to contrast the mean values at different stages of feeding when these were paired for comparison purposes. The results of the Scheffe tests are presented in Table 8.

As Table 8 illustrates, the SCR increased significantly ($p>.05$) between Baseline and Volition ($F=4.24$), and decreased significantly between Volition and Five Minutes ($F = 3.48$). There were no other significant increases or decreases between the different stages of feeding.

Conclusion

Statistical analysis of the data rejects the null hypothesis. Skin conductance response increased significantly between Baseline and Volition and decreased significantly, relative to Volition, by Five Minutes.

TABLE 7

ANALYSIS OF VARIANCE : SKIN CONDUCTANCE RESPONSE

N=20

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F
Between Subjects	3037.07	19	159.85	11.88
Within Subjects	807.30	60	13.46	
treatments	172.89	3	57.63	5.178
residual	634.41	57	11.13	
Total	3844.38	79		

TABLE 8
SUMMARY OF DIFFERENCES BETWEEN
PAIRED STAGE OF FEEDING MEANS :
SKIN CONDUCTANCE RESPONSE

COMPARISON	MEAN DIFFERENCE	SCHEFFE
Baseline vs Volition	-3.76	4.24*
Baseline vs Two Minutes	-1.23	4.56
Baseline vs Five Minutes	-.351	.037
Volition vs Two Minutes	2.53	1.91
Volition vs Five Minutes	3.41	3.48*
Two Minutes vs Five Minutes	.884	.234

*Significant at 95%

HYPOTHESIS 3

There will be no difference in breast temperature when observed at the following stages of feeding: Baseline, Volition, Two Minutes, and Five Minutes.

Findings

Table 9 presents the summary table for the analysis of variance performed relating stage of feeding and breast temperature. The observed F ratio was statistically significant ($F = 9.28$, $p < .0001$). The strength of the relationship was calculated using eta squared, which showed that after the effects of individual background had been removed, 65% of the variability in breast temperature was associated with stage of feeding. Given the significance of the F ratio, Scheffe tests were performed in order to contrast the mean values at different stages of feeding when these were paired for comparison purposes. The results of the Scheffe tests are presented in Table 10.

While mean breast temperature increased throughout the feeding (Table 4), Table 10 illustrated that significant increases ($p>.05$) occurred between baseline and Two Minutes ($F=7.17$) and between baseline and Five Minutes ($F=6.46$).

Conclusion

Analysis of the data rejects the null hypothesis. Breast temperature increased significantly, relative to baseline, at Two Minutes and Five Minutes.

TABLE 9
ANALYSIS OF VARIANCE : BREAST TEMPERATURE
N=19

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F
Between Subjects	143.29	18	7.96	5.99
Within Subjects	75.63	57	1.33	
treatments	25.73	3	8.58	9.28
residual	49.90	54	.92	
Total	218.92	75		

Note: 1 case deleted with missing values

TABLE 10
SUMMARY OF DIFFERENCES BETWEEN
PAIRED STAGE OF FEEDING MEANS :
BREAST TEMPERATURE

COMPARISON	MEAN DIFFERENCE	SCHEFFE
Baseline vs Volition	-.75	1.94
Baseline vs Two Minutes	-1.447	7.17*
Baseline vs Five Minutes	-1.37	6.46*
Volition vs Two Minutes	-.695	1.66
Volition vs Five Minutes	-.62	1.32
Two Minutes vs Five Minutes	.074	.019

*Significant at 95%

D. CONCLUSIONS

In summary, the null hypotheses were rejected. Finger temperature increased relative to stage of feeding. The skin conductance response increased significantly at Volition and showed a significant decrease between Volition and Five Minutes. Breast temperature increased significantly relative to stage of feeding.

The results of this study suggest that stage of feeding has a significant effect on finger temperature, skin conductance response, and breast temperature. Therefore, support is lent to the basic hypothesis that there are consistent patterns of significant observable peripheral physiological change which occur during breastfeeding.

CHAPTER FIVE
DISCUSSION AND IMPLICATIONS

A. CHAPTER OVERVIEW

The primary objective of this research was to record peripheral physiological responses during breastfeeding in order to more accurately describe what occurs during a feeding. More specifically, this study investigated whether there was any consistency among a group of successfully breastfeeding women in the pattern of their finger temperature, skin conductance response, and breast temperature at different stages of a feeding. Chapter 5 also discusses the results in relation to the objectives of this study and in terms of some of the implications for subsequent theoretical and applied research.

B. DISCUSSION

The results of this study indicate that physiological changes can be recorded during a feeding. This study has established a consistency in the patterns of women's responses at different stages of feeding. The current study suggests the viability of a psychophysiological approach in subsequent lactation research. Appropriate letdown reflex responses are critical to the success and

satisfaction of breastfeeding. Previous research suggested peripheral temperature increases during breastfeeding. Oxytocin theory suggested that these temperature changes might be temporally, if not functionally, related. This study extended and confirmed the data regarding peripheral change during feeding.

Finger Temperature

Relative to baseline and volition, finger temperature had increased significantly at two minutes and at five minutes. These results support anecdotal reports from mothers about having warm hands even in the middle of the night, and that "my hands are always cold except whenever I'm nursing." As previously noted, there have been virtually no studies in the area of finger temperature change during lactation. Studies have, however, been done relating oxytocin and vasodilation in the hand, and relating oxytocin flow during lactation. The correspondence between significant finger temperature increase in this study, and those times at which the literature reports a significant oxytocin increase after suckling, suggests a possible relation between increased finger temperature and oxytocin.

Finger temperature is generally interpreted as an indicator of sympathetic arousal. (Hartje and Farrar, 1984; Russell, 1972). Given this interpretive framework,

the finger temperature increases here would be interpreted as an inferred decrease in sympathetic arousal, at those times when the milk-ejection reflex is typically considered to have occurred.

Skin Conductance Response

The skin conductance response increased significantly at volition, and decreased significantly, relative to baseline at five minutes. As noted in Chapter Two, little psychophysiological research has been done on lactation. The skin conductance response is considered to be a "unidirectional measure of sympathetic arousal" (Feuerstein, Labbe, & Kuczmierczyk, 1986, p.65). Thus, increases in the SCR suggest increases in general sympathetic arousal level. If the milk-ejection reflex is inhibited by significant sympathetic arousal, how then can we explain a significant increase in the SCR among successfully breastfeeding women?

Edelberg (1961) reports tactile sensitivity was frequently enhanced following an SCR response. Could this then suggest that the elevated SCR response functions at a peripheral input level to facilitate the stimulation perhaps required to generate the MER? And on a parallel cognitive level if the initiation of a feeding leads to an arousal/ orienting response as manifested by the SCR, could this have the functional value of

deepening the mother's focus on the infant and the stimuli that contribute to the MER?

Much of the research on lactation has been based on animal research studies. In some respects this has been very useful. However, there are some problems with the application and generalization of this body of data to human mothers and infants. Comparative studies often focus on the distinction between inference based on analogy and inference based on homology: analogy referring to inference of similarity or correspondence based on functional similarities, and homology referring to inference based on structural similarity (von Cranach, 1975; Beer, 1984).

At first glance, studies in lactation would appear to be based on structural similarity, and at one level the similarities are great enough to be useful. But once we venture beyond the simpler levels of physiology into psychophysiology, the structural similarities blend into function, and the rationale for direct generalization becomes less clear.

Much of the animal data comes from rats and rabbits. Superficially the similarities suggest comparisons to humans: all are mammals, all lactate, all have a milk-ejection reflex that involves oxytocin being released in response to sensory stimulation. But when we look more

closely some interesting differences complicate generalization to human mothers. For rat pups to obtain milk, the mother must be asleep. If aroused to wakefulness, milk ejection does not occur (Lincoln and Paisley, 1982). Rabbits eject milk when awake, but only once a day, and are sometimes described as being unaware of events around them for that brief period. Given these differences, perhaps the most useful generalization to humans is that research in lactation may involve questions related to the regulation of arousal: that is, regulation of the balance between responding to sensory stimulation, and yet not being so stimulated by external stimuli as to not permit the reflex to function. In doing so, however, we have shifted our level of inference from homolog to analog, that is, from consideration of similarities in structure, to one of similarities of function. Additional human research is needed in this area before conclusions can be drawn.

Breast Temperature

Relative to baseline, breast temperature had increased significantly at two minutes and five minutes. These results support anecdotal reports from mothers about an upper body flush while nursing. Previous research observed breast temperature change in relation to stage of feeding. Abolins (1954) found a relationship

between increased temperature and milk volume. To the degree that the sample in the current study was comprised of successfully breastfeeding women who showed a significant mean temperature increase at two and five minutes, these results support Abolins' findings.

Using infrared thermography, Lind, Vuorenkoski, and Wasz-Hockert (1972) documented a significant increase in breast warmth when milk-ejection occurred in response to the sound of a crying baby, prior to suckling or the volitional initiation of feeding. The study was conducted in the immediate postpartum period, however, and the results in the current study may reflect the greater stability of the milk-ejection reflex in established lactation.

The rise in temperature at the breast may be related to increased blood flow at a time when the majority of the milk is being synthesized, thus increasing the availability of nutrients in the blood stream for milk production.

The results of this study indicate that physiological changes can be recorded during a feeding. This study has established a consistency in the patterns of women's responses at different stages of feeding. The current study suggests the viability of a psychophysiological approach in subsequent lactation research.

C. LIMITATIONS

Findings of the present study may have been limited by the following factors:

1. The reliability and accuracy of the measurement and recording equipment, particularly during electrical fluctuations.
2. The reliability of the data catch from the sensor-contacts.
3. Fluctuations in the temperature of the room.
4. Inconsistency in the period of time elapsed since the previous feeding.
5. Movement artifacts, particularly with the older, more active babies.

D. DELIMITATIONS

Findings of the present study were delimited by the following factors:

1. The sampling of subjects was limited to twenty mothers between the ages of nineteen and thirty-eight. This convenience sample was comprised of mothers selected from among those who volunteered for the study. No attempt was made at random or representative sampling by age. All mothers were from the greater Edmonton area.

F. IMPLICATIONS

In Applied settings

Assessment of breastfeeding adequacy and subsequent recommendations concerning supplemental feedings should consider the data regarding supplementation being equated with shortened duration of lactation, and consider intervention approaches that involve fostering the MER. One approach to milk-ejection reflex recovery is the pharmacological one suggested by Weichert(1979). Non-pharmacological approaches used by themselves, or as adjuncts to other interventions might utilize the results of subsequent research.

What may not be apparent to the external observer is that despite the importance of the MER to the maintenance of lactation many mothers are not aware whether or not the let-down has occurred. This neurohormonal sequence can and does operate beneath the level of awareness. It can, however, be brought into a woman's awareness. Mothers appear to learn to recognize the sensation of the let-down, that is, to discriminate it amidst the variety of incoming stimuli. Isbister (1953) reported that primiparous mothers didn't feel the let-down until 3 weeks postpartum. That experiencing the sensation of the let-down is not dependent on the milk supply being established is

suggested by multiparous mothers, who had nursed before, experiencing / reporting the MER's sensations much sooner.

External indicators of the let-down have for many years been used to help mothers notice/become aware of the let-down: dripping milk on the other side in the early stages of lactation; changes in the sucking/breathing pattern of the infant; increases in postpartum vaginal flow in the immediate postpartum period. Similarly, women have often been encouraged to try to relate the external indicators to subjective sensations: a feeling of fullness in the breast; a prickling or pins and needles sensation; an "on-rush".

The problem with these informal approaches is that they are not experience by all mothers in all circumstances: not everyone leaks after the first weeks; if the milk supply is low these sensations are less likely to be experienced; not everyone feels sensations like those someone else has experienced and can describe. The difficulty of articulating subjective sensations is akin to that of accurately describing the sensation of riding a bicycle so that someone else can learn how to balance. Thus an external indicator would have value, particularly for the mother for whom things are not going well.

If information about temperature change could help foster awareness of subjective sensations, and thus assist the mother in facilitating, or at least, not inhibiting the MER, then the first step was to document that temperature change occurs.

Is this in fact learning how to maintain optimal arousal? Is the discrimination learning of this stimulus (a la Miller, 1969) learning to recognize the sensation of the let-down, and to then permit sympathetic arousal and the MER?

The fact that many women learn to not permit the milk-ejection reflex under all circumstances is evidenced that after the first few weeks the majority of mothers do not leak nor spontaneously let down their milk except when they are about to feed their babies. Exceptions to this occur: when the breasts are extremely full and there is sufficient back-pressure to force milk from the lactiferous sinuses, and when women are orgasmic.

If not inhibiting the response, the mother would get feedback from the temperature increase that would tell her when even very tentative efforts were heading in the right direction. If the MER was functioning below the awareness of the mother, initial fingertip temperature shifts would give her feedback so that she could do more

of whatever is working, or attend to what ever internal/external stimuli seemed to be helping.

Given the possibility that finger temperature increases might function as an objective indicator of the MER, one possible application of these results would be the exploration of a biofeedback intervention using finger temperature. Working from Greenspoon's (l978) conceptual framework for biofeedback which revolves around awareness and self control, the MER seems an ideal opportunity / physiological sequence. Given that the MER occurs at an autonomic level beneath the conscious awareness of the mother, provision of feedback might support increased awareness, and in time greater self-control. Given also, that the MER is subject to inhibition via psyhophysiologic stressors, one would work to support a mother's efforts to not inhibit, but to permit the response, by doing "more" of whatever works to increase finger temperature.

For Subsequent research

The results from this study support the use of a psychophysiological approach to research into lactation. Various research directions arising from this preliminary study could be addressed.

1. Subsequent research in this area could address the variability which exists in the letdown response. Women could be grouped into underactive, average, and overactive response patterns, and the variability in peripheral change at different stages of feeding could then be investigated as it relates to apparent let-down reflex function. These results would explain not only the effect of stage of feeding on peripheral temperature and skin conductance response change, but would also explore the possible interaction of stage of feeding and let down group. Is it possible that the overactive letdown response could be eased by increased sympathetic tone, and the underactive letdown response by reduced sympathetic arousal.

2. Subsequent research in this area could involve serum sampling for oxytocin levels as they occur relative to peripheral temperature change. This would confirm the oxytocin levels relative to temperature change inferred in the present study. Elevations of finger temperature have been established as an objective

index of post-menopausal hot flashes (Meldrum, et al, 1979). Oxytocin serum sampling carried out in order to confirm the results of the current study might establish an equivalent use of finger temperature relative to the milk-ejection reflex.

3. Recent research has expanded our knowledge concerning neurotransmitters and neurohormonal reflexes, thus opening up a collaboration between neuro-physiology and biobehaviour. Subsequent correlational studies of thermal and skin conductance changes with peripheral hormone changes may help to explain hypothalamic mechanisms involved in the regulation of various reproductive processes.

4. Subsequent research might establish physiological baseline patterns in a series of modalities prior to and then concurrent with the baby's presence and suckling. These would provide information concerning similarities and differences within the letdown response groups based on an extended baseline profile. These would perhaps address questions of individual bracing patterns, levels of sympathetic arousal in different circumstances, and possible "performance" anxiety.

5. Subsequent studies might examine optimal arousal levels in breastfeeding mothers. The SCR increase might be equated with orienting to stimulation from the

infant, or it might be a response to the sensation of the letdown itself, which can startle and is novel. (When discussing the letdown many years after weaning, women seem to focus internally and then to describe the subjective sensation itself, not the baby/circumstances of the nursing experience.) What is the skin conductance pattern among less successful breastfeeding women? Would differences in recovery time from initial increase give us an indicator of self-regulation among successfully lactating women? Similarly, subsequent research could involve EEG recording while nursing to elaborate the data about arousal level from the comparative lactation studies.

6. Subsequent research might consider potential applications in which feedback to foster the letdown would be of enormous value. Ruis et al (1981) describes the difficulty in establishing and maintaining lactation among prematurely delivering mothers who wish to provide milk for babies too small or weak to suckle. Several articles address the need to foster the letdown reflex in relactation situations (Auerbach and Avery, 1980; Bose, D'Ercole, Lester, Hunter, and Barrett, 1981; and Ferrari, Acland. Ferrarri, Suna, and Gerpe, 1981). Down's syndrome babies are generally difficult to breastfeed since, consistent with their hypotonic

pattern, they tend not to suck vigorously (Aumonier, 1983). Stewart and Gaiser (1978) describe methods to support lactation when mothers and infants are separated. They stress the importance of the letdown in adequately emptying the breasts of milk in the absence of suckling. Meites (1974) provides the general perspective for subsequent lactation studies in this area: given our knowledge of the neuroendocrine control of lactation, subsequent research should attempt to apply this knowledge to the treatment of problems in lactation via management techniques that utilize the knowledge gained.

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Appendix A

Background Information Checklist

1. parity and age of mother? menstruating?
2. history of difficulties carrying to term, conceiving, irregular periods?
3. smoke?
4. age of baby
5. weight at birth
6. most recent weight/what age?
7. 6 week check? no problems? D&C...?
8. solids? supplement? sleeps through?
9. other? difficulties initiating lactation? /individual patterns of mothering ?/ what is this baby like compared to her others? unique suckling pattern?/ diurnal pattern of this child?/ other comments?
10. identification code: